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NIGHT VISION GOGGLES OPERATIONS WEATHER SOFTWARE (NOWS)

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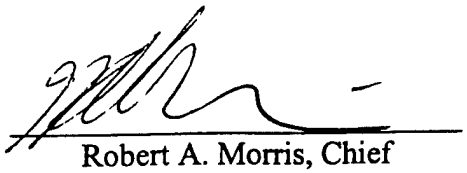

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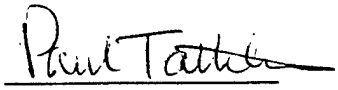

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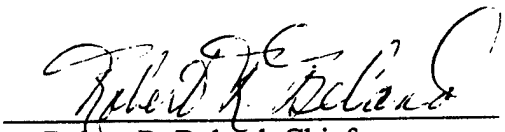

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13. ABSTRACT *(Maximum 200 words)*

This report summarizes progress on the development of NVG Operations Weather Software (NOWS) from September 1997 through August 1998. NOWS is designed for use by DoD meteorologists to support forces performing covert operations using NVGs. The types of missions that are supported include helicopter refueling, target acquisition/detection, take-off and landing, identification of pickup/drop zones, and search and rescue. NVG performance predictions are made for specified missions and forecasted local weather conditions. NOWS also provides solar and lunar ephemeris information for a series of times or dates at a user-specified location. NOWS is being developed incrementally to include state-of-the-art physical models, a modern graphical user interface, and access to geographic and meteorological databases to provide accurate results, maximize usability, and minimize the amount of input data that must be entered manually by a user. This report describes progress made in the areas of NOWS system design, user interface, physical models, and model assessment.

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1. INTRODUCTION

Air Force/Department of Defense (DoD) meteorologists have a need to support forces performing covert operations using Night Vision Goggles (NVGs). The types of missions that require support include helicopter refueling, target acquisition/detection, take-off and landing, identification of pickup/drop zones, and search and rescue. A single mission may include several of these tasks. Mission planners and pilots need to know if it is possible to conduct their missions under low light level conditions using NVGs. NVG performance predictions are required for specified missions and forecasted local weather conditions. These performance predictions can be used by mission planners to make "go/no-go" decisions, to modify mission execution tactics, or to evaluate the general suitability of environmental conditions for NVGs. The performance predictions can be used by pilots to prepare for the expected conditions during a mission or training exercise.

The purpose of this contract is to incrementally develop and deliver a practical and user-friendly NVG Operations Weather Software (NOWS) package for use by Special Operations and ACC weather support personnel. State-of-the-art physical models, a modern Graphical User Interface (GUI) development environment, and geographic and meteorological databases are being utilized to provide accurate results, maximize usability, and minimize the amount of input data that must be entered manually by the user. Additional activities involve the development of a three-dimensional scene visualization capability and assessment of the accuracy of the NOWS physical models using field data.

The work is divided into four task areas. A brief description of the task areas is provided below.

Task 1 Basic NOWS Development. This task represents the core of the project activities. In this task, the NOWS system is being incrementally developed in three stages: initial development, advanced development, and future enhancements. Both the physical models and the GUI are being developed and improved at each stage.

Task 2 Model Assessment. The NOWS physical models are being evaluated using field measurements collected in a program which TASC helped develop. TASC performed a quick-look assessment of the instrumentation requirements and developed an assessment plan. TASC is responsible for assessing the physical models. The government is responsible for acquiring and setting up equipment and for collecting the data.

Task 3 Prototype Scene Visualization Development. This activity will develop a prototype capability to create synthetic images of three-dimensional scenes using results from the NOWS physical models and three-dimensional target and terrain data.

Task 4 Documentation. This task provides for project technical and financial status reports, periodic briefings to describe project status and to review system designs, and software User's Manuals.

The NOWS tasks are being completed over four and a half years. The NOWS project schedule is shown in Figure 1.

This report is the fourth Interim Report for Contract Number F19628-94-C-0201, prepared and submitted by TASC. This report covers the period 1 September 1997 through 31 August 1998. Progress in each of the four task areas during the fourth year of the contract is described, as well as plans for the remaining one-half year of the contract.

1.1. PROGRESS SUMMARY

During the fourth year of the project, progress was made on Tasks 1, 2, and 4. The progress made on each of these tasks is summarized briefly in the sections below. Task 3 was deferred by the Air Force Research Laboratory (AFRL).

1.1.1. Task 1: Basic NOWS Development

This task involves incremental development of the NOWS system in three stages: initial development, advanced development, and future enhancements. In each stage, development occurs in three areas: system design, user interface, and physical models. In addition, alternative physical models are being evaluated and software is being delivered.

During the fourth year of the project, TASC continued work on the future enhancements stage. TASC migrated from the Visix GALAXY cross-platform development environment to the Microsoft Visual C++ environment. The Graphical User Interface (GUI) was re-designed, and work on Version 5 progressed. Work in these areas is described in Section 2 of this report.

1.1.2. Task 2: Model Assessment

This task involves evaluation of the NOWS physical models using field measurements. Work is being performed in three areas: a quick-look evaluation of the instrumentation required to assess the NOWS physical models, development of an assessment plan, and implementation of the assessment plan.

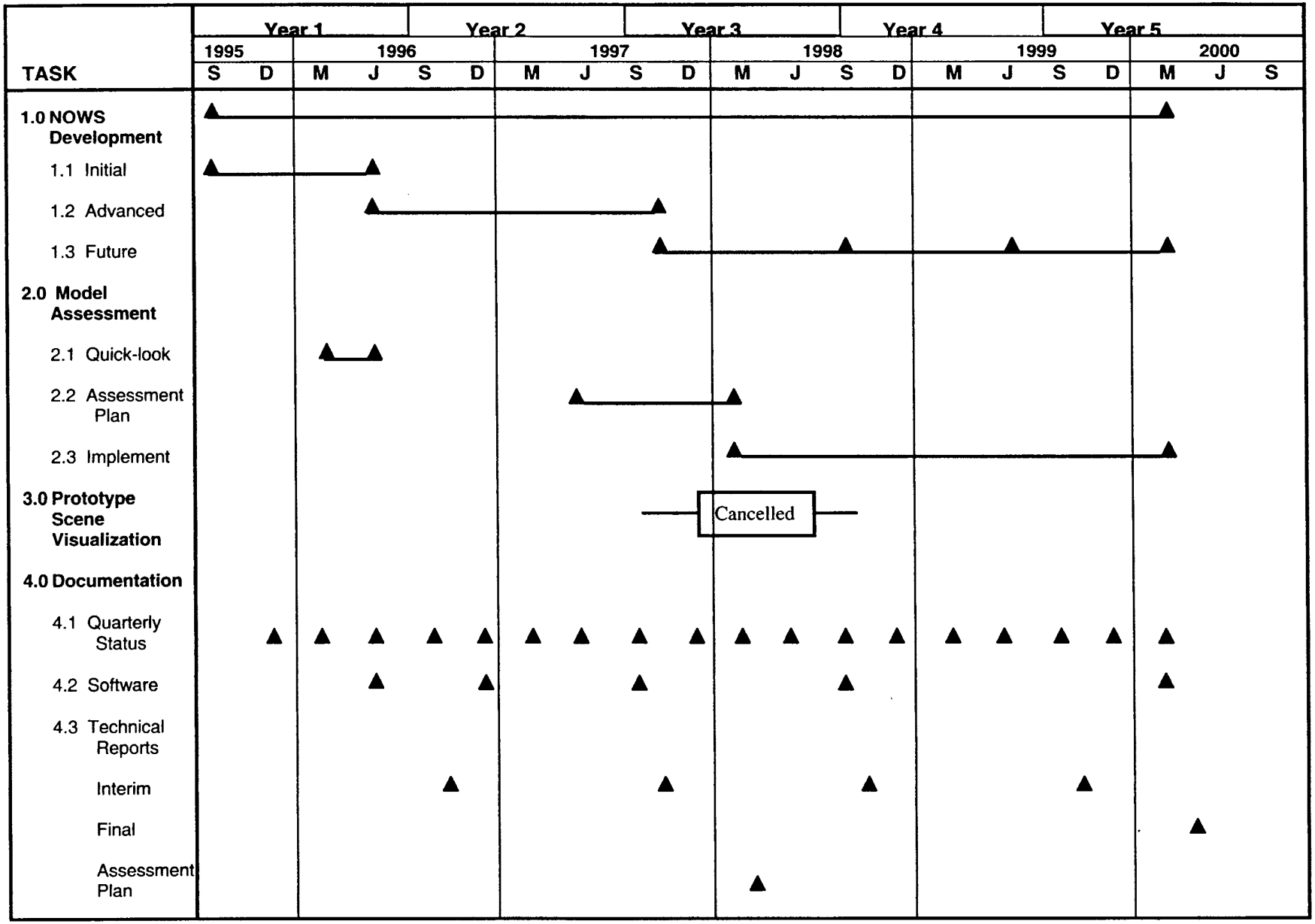

Figure 1. NOWS Project Schedule.

During the fourth year of the project, TASC completed a detailed analysis of the first two sets of data from the Otis ANGB field site. Work in this area is described in Section 3 of this report.

1.1.3. Task 4: Documentation

This task involves preparation of quarterly project technical and financial status reports, periodic briefings to describe project status and to review system designs, annual Interim Reports, and development of software User's Manuals to accompany each incremental software delivery. Work in these areas is described in Section 4 of this report.

1.2. REPORT ORGANIZATION

This report contains five main sections. Section 2 describes the progress made during the fourth year of the project on Task 1, Basic NOWS Development. Section 3 describes the progress made during the fourth year of the project on Task 2, Model Assessment. Section 4 describes the progress made during the fourth year of the project on Task 4, Documentation. Finally, Section 5 discusses plans in each of these task areas for the upcoming year.

2. TASK 1: BASIC NOWS DEVELOPMENT

This task involves incremental development of the NOWS system in three stages: initial development, advanced development, and future enhancements. During the first year of the project, TASC completed the initial development stage and began work on the advanced development stage. During the second year of the project, TASC completed the advanced development stage. During the third year of the project, TASC began the future enhancements stage; this stage was continued during the fourth year. Progress made during the fourth year of the project is described in the following subsection.

2.1. NOWS ENHANCEMENTS

During the fourth year of the project, this third stage of the three-stage effort involved significant modifications to the NOWS system design, a revised user interface, and further development of the physical models. Highlights of the fourth year included conversion to a Microsoft Visual C++ development environment and preparation of Version 5. Work in these areas is described below.

2.1.1. System Design

Changes to the NOWS system design for Version 5 were driven by the demise of Visix, the company providing our cross-platform GALAXY development environment. TASC's recommendation to convert to the Microsoft Visual C++ development environment was accepted by AFRL. In addition, customer feedback on NOWS Version 4 indicated that the GUI was cumbersome. Several requests for a faster NOWS process were received. The conversion to Microsoft Visual C++ and the requests to implement a faster NOWS process led to a redesign of the NOWS GUI. Additionally, TASC learned that the XRT graphics package and the Digital Chart of the World (DCW) mapping data used by previous versions of NOWS were no longer supported, requiring a new graphics package and new mapping data. Design work in these areas is described in the subsections below.

2.1.1.1. Conversion to Microsoft Visual C++ and NOWS GUI Redesign

Visix, the company that developed the GALAXY cross-platform development environment used for the NOWS GUI, went out of business in March 1998. TASC evaluated

several options for the continued development of the NOWS GUI: continuing with GALAXY in spite of the lack of future support and upgrades; rehosting the NOWS GUI in Microsoft Visual C++; and using a combination of the two. TASC presented its findings to AFRL on 9 April 1998. We found that using GALAXY and Visual C++ together was not feasible, due to incompatibility of the underlying controls and objects. We recommended to AFRL that we transition NOWS to Visual C++. The advantages of this approach were many: better support for Windows 95/NT and future versions of Windows; easy access to standard GUI controls such as buttons, menus, wizards, tabs, dialog boxes, etc.; ability to adopt a standard Microsoft product look-and-feel; and better code maintainability. AFRL concurred, and we began to work hard on re-developing the GUI in Visual C++.

TASC reexamined the object-oriented software design that was developed during the first year of the contract (Gouveia and Higgins, 1996). Several changes were made to the design, to streamline the core code and make relevant components of the code more portable to the Target Acquisition Weather Software (TAWS), being developed concurrently for AFRL. The major change to the design was the incorporation of a new single point-based "quick" target analysis. This analysis type is designed to allow a user to quickly obtain results for a single target, without going through the steps of choosing a region and setting up a mission.

2.1.1.2. Conversion of Graphics Package

XRT, the graphics package used in previous versions of NOWS, is not supported by Microsoft Visual C++ or newer versions of GALAXY. This required the conversion to a new graphics package. TASC evaluated a series of packages, and recommended the selection of OlectraChart as the NOWS/TAWS graphics package. AFRL concurred, and purchased the software for the program.

2.1.1.3. NOWS Map Data

Previous versions of NOWS used the DMA Digital Chart of the World geographic database for low- and high-resolution maps. NIMA has replaced DCW with Vector Map Levels 0, 1, and 2. Currently, only Level 0 contains reliable global data. The NOWS maps, therefore, were updated to use Vector Map Level 0 (VMap0) and re-hosted in Visual C++. In response to AFRL feedback on NOWS Version 4, TASC included labeled latitude/longitude lines on the map and a map properties dialog to allow the user to select multiple map features at once.

2.1.2. User Interface

Changes to the NOWS GUI for Version 5 focused on two key areas: re-development of the GUI in Visual C++ and the new single point-based "quick" target analysis. Work in these areas is described in the subsections below.

2.1.2.1. Conversion to Microsoft Visual C++

TASC conducted a top-down evaluation of the existing NOWS GUI, identified which parts of NOWS could be considered "core code", and which parts performed underlying processes and calculations. We identified the tools available with Microsoft Visual C++ and identified which of those tools could be effectively used for a new NOWS GUI.

As TASC evaluated the options available for the NOWS GUI in Visual C++, several potential changes were identified to the look and feel of NOWS. Some of these new capabilities were used to make NOWS look more like a standard Microsoft Windows 95/NT product. This also makes the NOWS process faster and easier to learn for a user since most are familiar with Windows products. Prototypes of the new NOWS GUI were presented to AFRL throughout the period for periodic evaluation and approval.

Examples of the Windows "look-and-feel" implemented for NOWS Version 5 include using the menu bar to allow standard save and print functions. NOWS progress charts were replaced with wizards. Tab dialogs were implemented wherever possible to make input screens more compact. Minimize, maximize, and close buttons were enabled on all windows, and users can now display multiple windows on the screen controlled by the menu bar and buttons. The sliders used for NOWS user inputs were replaced by spinners, which are easier to use and provide the added capability for a user to type in values directly. Many of these improvements were made in response to comments received on NOWS Version 4.

2.1.2.2. Single Point-Based Analysis

The single point-based analysis type is being added to allow a user to quickly obtain results for a single target, without going through the steps of choosing a region and setting up a mission. A new interface is required for this, and TASC is putting together a design that will work with only minor modifications for both NOWS and TAWS.

2.1.3. Physical Models

For NOWS Version 5, only small fixes to the physical models are being made.

2.1.4. Evaluation of Alternative Physical Models

During year four, work in this area was given a lower priority.

2.1.5. Incremental Software Delivery

Incremental software development is a key element of our approach to developing the NOWS system. Incremental development provides a product to the user for evaluation as soon as possible. This means that feedback is received sooner and responses to the feedback are implemented sooner. The system evolves surely and quickly towards the desired endpoint. The NOWS project schedule provides for five major, incremental software deliveries over the contract period.

The fourth incremental software delivery occurred with the delivery of NOWS Version 4.0 on 29 August 1997. An update to Version 4.0, together with the reproducible User's Manual, was delivered on 31 October 1997. A second update was prepared and delivered on 24 November 1997. Feedback on NOWS 4.0 from AFRL and field users was received during this reporting period, and is affecting changes for the Version 5.0 release due in February 1999.

2.1.5.1. Software Changes

The following changes were made to the Version 4.0 software during the past year:

- The ability to access NIMA's Digital Aeronautical Flight Information File (DAFIF) through the NOWS illumination goal to obtain latitude and longitude coordinates for any airport or heliport worldwide
- Support for the half-hour time zone offsets from UTC in the NOWS illumination goal
- Improvements to the timeline output product for solar/lunar event times in the illumination goal
- Support for local or UTC time, as well as noon-to-noon or midnight-to-midnight analysis in the illumination goal
- Updates to all NOWS tabular output products, so tables appear in spreadsheet format rather than ASCII text format
- Fixes to an error that sometimes caused the background map to be blank
- Fixes to small errors in the appearance of several NOWS tables and the timeline output product
- Fixes to two errors in DTED search algorithms

3. TASK 2: MODEL ASSESSMENT

This task involves evaluation of the NOWS physical models using field measurements. Work is to be performed in three areas: a quick-look evaluation of the instrumentation required to assess the NOWS physical models, development of an assessment plan, and implementation of the assessment plan. During the first year of the project, TASC completed the quick-look evaluation. During the second year of the project, TASC began developing an assessment plan. During the third year of the project, TASC completed the assessment plan and began its implementation by developing a baseline assessment testbed. During the fourth year, initial assessments were completed. Progress is described in the following subsection.

3.1. INITIAL ASSESSMENTS

During the fourth year of the project, TASC began a detailed analysis of the first two sets of data from the Otis ANGB field site. This data was compiled by AFRL for two time periods: 23, 25, 27, and 30 June 1997; and 22 September, 1, 3, and 6 October 1997. A format for the data package to be used for the presentation of results for each night's experiments was devised. TASC obtained soundings from Chatham to supplement the soundings from Otis. We tweaked the algorithm for obtaining the boundary layer height from a sounding, but realized that this parameter will often need to be adjusted manually. During the analysis of the June data, TASC uncovered some problems with the model assessment testbed, which were subsequently fixed. TASC also obtained the latest version of MODTRAN and got it up and running for future comparison studies. The analysis of the data focused on two objectives: 1) check for consistency among observations and 2) compare measurements to NOWS model predictions. Results were presented by TASC to AFRL on 20 February 1998. Conclusions are summarized below.

3.1.1. Consistency Between Observations

Consistency checks were designed to compare data between similar cases and to compare data collected by AFRL to data from other sources. TASC reached the following conclusions:

- In general, the measured transmission data were highly inconsistent. AFRL agreed that there were problems with these measurements.
- The measured visibility data seemed high on a few nights of the second data set. Comparison of the measured visibility data with surface observations at

Falmouth showed reasonable agreement for visibilities less than 15 miles; 15 miles is the maximum visibility presently being recorded at Falmouth.

- The measured total night sky irradiance data was not consistent from case to case. For two nights with similar weather conditions, total night sky irradiance data were lower for the night with higher visibility and lower relative humidity.
- The measured total night sky irradiance data were of the same order of magnitude as data presented by Vatsia (1972) but did not show the same spectral structure. See Figure 2.
- The measured total night sky irradiance data showed similar spectral structure to data presented by Schemine (1993) but were an order of magnitude lower. Schemine did indicate that the measurements were likely contaminated by urban illumination (1993). See Figure 3.

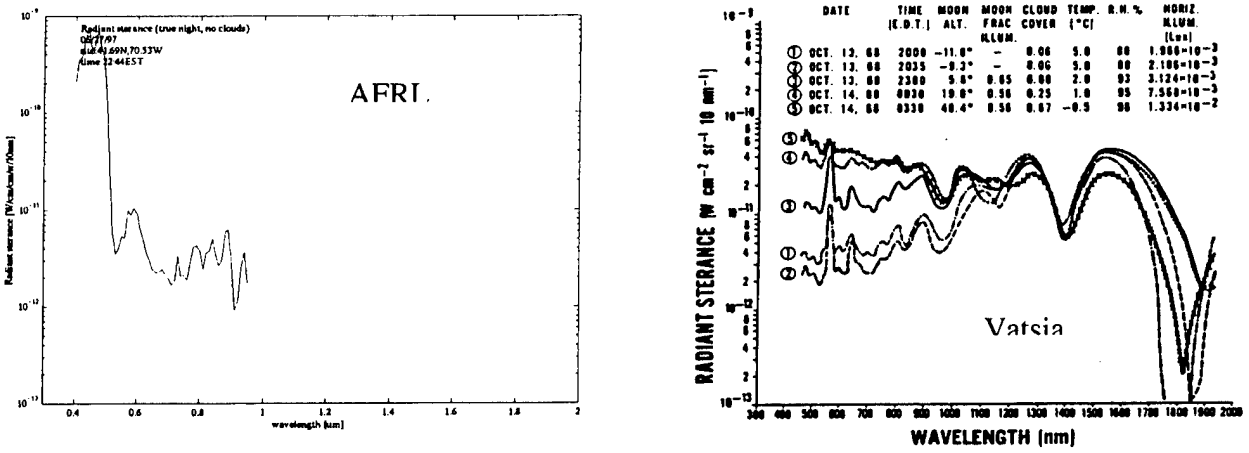

Figure 2. Comparison of AFRL Data to Vatsia (1972).

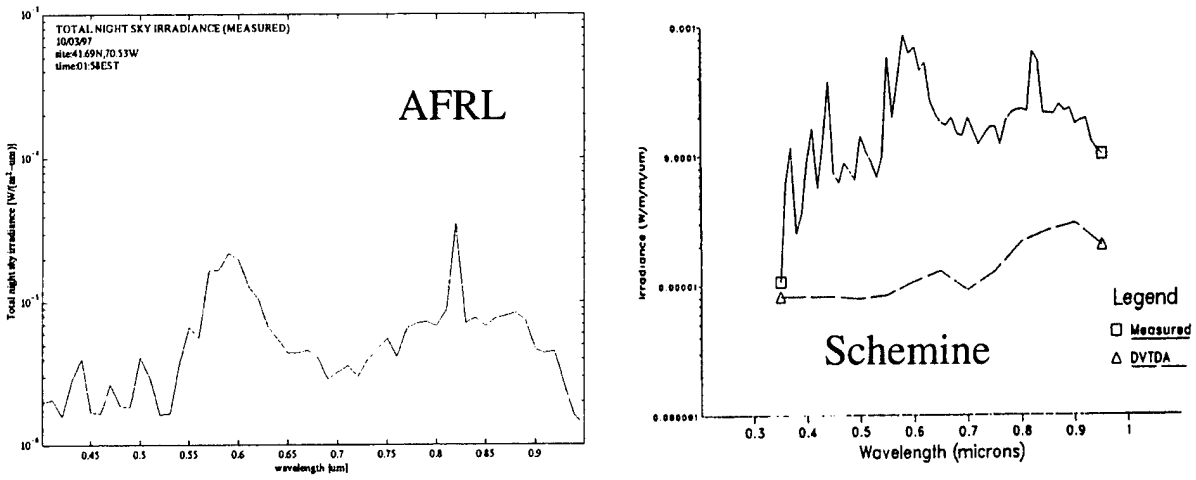

Figure 3. Comparison of AFRL Data to Schemine (1993).

We suggested several possible explanations for inconsistency in the data:

- Calibration of the transmissometer.
- Calibration of the radiometer used to measure the total night sky irradiance.
- Light pollution, giving rise to spectral peaks at 0.45, 0.59, and 0.82 μm.
- "Similar weather conditions" for night-to-night comparisons were not close enough.

Overall, we were pleased with the similarities between the AFRL data and the data presented by Vatsia (1972) and Schemine (1993).

3.1.2. Comparisons between Observations and NOWS Model Results

Comparisons between measured data and NOWS model predictions were designed to focus on similarities and differences for total night sky irradiance. Due to consistency problems with the measured transmission data, TASC postponed evaluation of this parameter for now. The following conclusions were reached:

- The best agreements between measurements and model predictions for total night sky irradiance occurred on the nights of 27 and 30 June and 3 October.
- NOWS overestimates the total night sky irradiance at all wavelengths for moonlight and twilight conditions.
- In most cases, NOWS tends to overestimate the total night sky irradiance at higher wavelengths for true night conditions.

- The measured total night sky irradiance tends to show spectral peaks at 0.45, 0.59, and 0.82 μm. NOWS predictions do not.

TASC proposed and investigated several possible explanations for the differences between the measured total night sky irradiance data and the NOWS model predictions:

- Experimental error. The calibration of the transmissometer or the radiometers may be faulty.
- Analysis error. We thought that the NOWS predictions may have been affected by incorrect specification of the boundary layer height, incorrect specification of the upper layer aerosol, or incorrect computation of the average upper layer temperature and relative humidity. Further investigation, however, showed that these factors could not explain the differences between the measured total night sky irradiance data and the NOWS model predictions. Other areas to investigate include the effects of incorrect specifications of the surface aerosols.
- Model error or approximations. We thought that the spectral resolution of the NOWS sensor performance model might not be sufficient to capture peaks at 0.45, 0.59, and 0.82 μm. However, further investigation showed that with increased resolution, the model still did not reproduce these peaks. We thought that the peaks at 0.45, 0.59, and 0.82 μm might be due to urban illumination. Further investigation showed that the NOWS urban illumination model could not capture these peaks. Other areas to investigate include: the spectral resolution of the NOWS atmospheric transmission model, the spectral characteristics of the NOWS urban illumination model, other sources of light pollution (such as point sources), the use of "average" cloud properties, the value of the lunar source term, and the two-layer atmosphere approximation. Comparisons with MODTRAN will help with some of these studies.

TASC intends to continue investigating the source of differences between the measured total night sky irradiance data and the NOWS model predictions for these data sets. We will try to determine if the differences are primarily due to the direct or diffuse components of total night sky irradiance. We will also look for similar trends in more recent data sets collected by AFRL.

4. TASK 4: DOCUMENTATION

This task involves quarterly project technical and financial status reports, periodic briefings to describe project status and to review system designs, annual Interim Reports, and development of software User's Manuals to accompany each incremental software delivery. Progress made in these areas is described in the following subsections.

4.1. QUARTERLY PROGRESS REPORTS

We provided four quarterly progress reports during the fourth year of the contract, covering the period 1 September 1997 through 31 August 1998. These reports included information about project technical and financial status. The reports covered work performed from 1 September through 30 November 1997, 1 December 1997 through 28 February 1998, 1 March through 31 May 1998, and 1 June through 31 August 1998.

4.2. PERIODIC BRIEFINGS

Periodic briefings were given to describe project status and to review system designs. A project status briefing was given to AFRL on 9 April 1998. The NOWS Version 5.0 preliminary software was demonstrated to AFRL on 30 July 1998.

On 20 February 1998, a review of assessment activities was held at AFRL.

TASC accompanied AFRL to demonstrate NOWS at the Night Vision USA Conference and Exhibition in Arlington, VA, on 9-10 October 1997. TASC gave a briefing and demonstration of the NOWS product at the Weather Impact Decision Aids (WIDA) meeting at Langley AFB on 24-25 March 1998. NOWS received a favorable reception at the meeting. On 26 March 1998, we met with representatives of AFSOC, ACC, and AFWA to obtain feedback about NOWS Version 4.

4.3. SOFTWARE USER'S MANUAL

The final, reproducible copy of the NOWS Version 4.0 User's Manual was delivered on 31 October 1997. An electronic copy of this manual was also included with the NOWS Version 4.0 software delivery.

5. PLANS FOR REMAINING ONE-HALF YEAR OF CONTRACT

Plans for the remaining one-half year of the contract center on the production and delivery of NOWS Version 5.0 in February 1999. The NOWS project is scheduled to end on 31 March 1999; however, discussions have taken place to extend the NOWS effort for one additional year to address changes to NOWS Version 5.0 in a NOWS Version 6.0. Additionally, work would continue on the NOWS assessment effort. If approved, a prioritized list of objectives and work areas will be developed with AFRL.

5.1. TASK 1: BASIC NOWS DEVELOPMENT

Task 1 represents the core of the project activities. As indicated in Figure 1, the NOWS system development will proceed through three phases: initial development, advanced development, and future enhancements. During the remaining one-half year of the contract, we will continue the future enhancements phase.

5.1.1. Future NOWS Enhancements

As we continue the development of NOWS, improvements will be made in a number of areas, including system design, user interface, and physical models. The fifth incremental delivery of NOWS is planned for February 1999. If the NOWS effort is extended to include a sixth incremental delivery of NOWS, then work would begin on this during the next year.

5.1.1.1. System Design

System design work for NOWS Version 5 is nearly complete. One major upgrade that will affect the NOWS system design is the addition of a capability to access weather data from AFWA. We will work with AFRL and AFWA to identify design options for an automated weather data download capability.

Potential upgrades that could affect the system design for NOWS Version 6 include adding the ability to access and use a climatological database, the addition of a weather data ingest step for illumination analysis, including a customized target option where a user could define the height, for example, of a radio tower flight hazard, and adding map-based output products. The priority of any changes will be established with assistance from AFRL.

5.1.1.2. User Interface

Many changes will be made to the NOWS GUI for Version 5. The new system design will continue to be implemented in object-oriented code. Efforts will focus on the map-based key location analysis, the illumination analysis, and the new single point-based "quick" target analysis.

For NOWS Version 6, there are a number of potential major upgrades that would affect the user interface. The priority of these changes would be established with assistance from AFRL.

5.1.1.3. Physical Models

For NOWS Version 5, only small fixes to the physical models will be made.

For NOWS Version 6, there are a number of potential upgrades to the physical models. These could include adding the ability to support user-specified paint colors for targets, incorporating terrain effects on target detection, accounting for windshield effects on target detection, supporting a weather dependence for illumination analysis, and adding true support for a horizontal path. Other potential changes would be dictated by results of the model assessment activity. The priority of any changes would be established with assistance from AFRL

5.1.1.4. Incremental Software Delivery

One major release of NOWS is planned for next year. NOWS Version 5 is scheduled for delivery on 28 February 1999.

5.2. TASK 2: MODEL ASSESSMENT

The model assessment activity is an important component of the NOWS project and represents a joint effort between TASC and AFRL. During the remainder of the contract, TASC is responsible for evaluating the assessment data collected by AFRL and identifying problems with the current NOWS physical models.

5.2.1. Implementation of Assessment Plan

TASC will continue to assist AFRL with the implementation of the assessment plan during the remainder of the contract. Utilizing data collected by AFRL, we will exercise NOWS models and compare model output with field data. We will pay particular attention to some of the assumptions made by NOWS, such as modeling the atmosphere in just two layers and using

the temperature at 500 mb from automated weather data sources as the average upper layer temperature.

5.3. TASK 4: DOCUMENTATION

Planned documentation for the next interim report period includes Quarterly Progress Reports and the User's Manual associated with each software delivery. Other informal briefings and technical reports will be prepared as necessary.

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